The Influence of Lobby Groups on Public Opinion: The Case of Environmental Policy.

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Abstract

What role does the provision of information by special interest groups play in changing public perceptions about environmental issues, and on the formation of public policy? To date, much of the environmental policy literature has focussed on lobbying efforts by special interest groups in which direct policy contingent contributions are made to the government. However, spending by special interest groups, in particular those representing environmental concerns, is often not directed towards the government, but instead towards policies aimed at influencing the public's beliefs regarding the extent and severity of environmental damage. This paper presents a model of strategic lobbying of the government and the public by special interest groups with opposing environmental concerns. Building on Yu (2005), we consider the case where a polluting firm and an environmental lobby send costly messages to a relatively uniformed public about environmental damage (indirect lobbying). At the same time, the firm can engage in direct lobbying of the government by making policy contingent contributions (direct lobbying). As such, the common agency framework of Grossman and Helpman (1994) is combined with the literature relating to signalling. The results reveal that separating equilibria exist where the public will learn the true level of environmental damage. The strategic importance of indirect lobbying as a means by which environmental concerns can curtail the political influence of polluters is also established. Finally, direct and indirect lobbying by the polluting firm are found to be strategic complements, but this is shown to occur only under limited circumstances.

* This paper is adapted from a chapter in my PhD dissertation undertaken at the University of Adelaide. I would like to thank my supervisor, Richard Damania for his assistance and feedback. My appreciation also to Stephen King, John Whitley, and Zhihao Yu for comments on previous versions of this paper. The usual disclaimers apply.
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1. Introduction

Grossman and Helpman (1994) present a menu auction model of endogenous trade protection in which lobby groups are able to 'buy' better trade policy outcomes by making direct contingent contributions to the incumbent government. In this approach, contributions are made to politicians in order to induce them to adopt policies which deviate from the welfare maximising ideal. This model been applied to a wide range of policy issues and has received substantial empirical support.[1]

There have been several applications of Grossman and Helpman's model to the analysis of environmental policy.[2] In these models, rival polluting and environmental interests typically compete with one another by making contributions to government. Greater policy concessions are shown to fall the way of those groups who have a greater stake in the policy issue (and who have a greater preparedness and ability to pay).

Interestingly, contributions made by interest groups with environmental concerns are dwarfed by those of polluting interests. For example, during the 2002 election cycle in the U.S., environmental groups contributed $US1.4 million compared with total contributions by the energy and natural resources sector of $US57.8 million.[3] How might we interpret this? In theory, this could suggest that environmental groups stand to gain little by influencing environmental policy. However, their actions would not seem consistent with this view. In particular, spending of environmental groups seems to be directed towards other types of activity. For example, during the period 2001/2002, the Sierra Club spent $US77 million dollars on programmes designed to combat environmental damage, some of which involved directly educating members of the public. Perhaps most striking is that only $US518,871, or 0.67% of this expenditure took the form of political contributions.[4,5] This pattern of expenditure would suggest that the ability or

[1] For example, see Gawande and Bandyopadhyay (2000); Goldberg and Maggi (1997); Mitra *et al.* (2002) ; McCalman (2004).
[2] See, for example, Fredriksson (1997, 1999), Aidt (1998), Schleich (1999) and Damania (2002).
[3] Of this, $US24.9 million and $US21.5 million were contributed from the 'Oil and Gas' and 'Electric Utilities' respectively. For more details, see www.opensecrets.org and www.opensecrets.org/payback/issue.asp?issueid=EN2&&&&CongNo=108 , accessed 11/3/04.
[4] Details of political contributions obtained from www.opensecrets.org , accessed 11/3/04. Expenditure details taken from the Sierra Club Foundation 2002 Annual Report, available online at www.sierraclub.org/foundation/inside/tscf2002.pdf , accessed 11/3/04.

willingness of the Sierra Club to use such contributions is limited. Nonetheless, environmental groups like the Sierra Club do appear to have significant influence over policy outcomes. The data thus suggest that direct political contributions are not the sole way by which special interests can influence policy outcomes.

The premise behind any democracy is that public policy will reflect the beliefs and preferences of citizens. However, public policy is made up of a myriad of complex issues and it is well established that voters will not find it optimal to become fully informed about each.[6] Public policy outcomes are to some extent a function of how informed or uniformed the public are of the relevant facts. This is especially relevant in the case of environmental policy, where there is often debate over the nature and extent of environmental damage, leading to uncertainty in the minds of the public. It is thus somewhat surprising that with the notable exception of Yu (2005), the role of special interest groups in providing information to the public has been somewhat overlooked in the environmental policy literature.

There are some studies which examine the role of information in other settings. One arm of this literature considers how mass media effects voting behaviour and policy outcomes. In a model examining the influence of mass media, Stromberg (2004) finds that there is a bias in the provision of information towards numerically larger groups in society. As rival politicians respond to changes in voter awareness by altering their policy positions, public policy tends to be biased against smaller groups who remain relatively uninformed.[7]

The role of information in the case of wage arbitration has also been investigated. In Farber (1980) an arbitrator has a predetermined idea of what a ‘fair wage’ would be and choses from the bids submitted by rival parties the one which is closest to this ideal. Obviously, the parties face a lower probability of having their offer accepted the more extreme it is. Gibbons (1988) extends this framework by allowing the arbitrator to update her beliefs after receiving messages.

Several studies use a signalling framework similar to that of Spence (1973). Building on Crawford and Sobel’s (1982) model of costless signalling, Grossman

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[5] A recent contribution by Yu (2005) notes that in the 1990 US election cycle, the proportion of political contributions to total spending by the same group was below 6% and that the trend for this type of expenditure was one of decline. The data from 2001/2002 tend to support this view.

[6] This turns on the fact that the probability of an individual influencing an election outcome with their vote approaches zero. For discussion of this see Olson (1965), Rodrik (1995).

[7] As the parties adjust to learning by the public, mass media is shown to have little influence over voting behaviour. This result is consistent with empirical evidence (see for example Bartels, 1993).

and Helpman (2001) consider the role of communication by special interest groups to a relatively uniformed public. The purpose of this communication is to sway voter opinion (and thus policy outcomes) in their favour before politicians settle on a final policy. Each of the lobby groups thus has an incentive to exaggerate their claims regarding the impacts of policy on the public at large. The public use a Bayesian mechanism to update their beliefs once messages are received. It is found that provided the messages are not too extreme – that is, do not deviate 'too much' from the prior beliefs of the public, interest groups can effect a change in beliefs. The issue of costless signalling is also considered by Schultz (1995), who considers the issue of information provided by relatively well informed politicians to a less informed public regarding the workings of the economy. The analysis centres around the circumstances under which the public may or may not learn from these messages. It is found that polarisation of the opposing parties tends to make the public sceptical about their claims and as such, they remain uniformed. It is argued that such societies incur a cost from political polarization as the resultant policy outcomes will be inelastic to exogenous shocks to the economy.

By far the most relevant piece of research to the model presented in this paper has been undertaken by Yu (2005). Like this study, the aim of his paper is to provide a model whereby special interest groups can influence policy by changing public perceptions regarding environmental damage. In his paper, two opposing special interest groups try and influence environmental policy by making political contributions (direct lobbying) to government and/or sending messages to an uncertain public regarding the environmental damage which results from polluting activities (indirect lobbying).[8] An important feature of the model is that messages are costly to send, as opposed to the studies discussed previously, which tend to approach the problem as a 'cheap talk game'. Yu's analysis yields some interesting results. First, it is found that where the costs of sending messages are identical for both groups, the party who is more active in direct lobbying will also expend greater effort in indirect lobbying. However, the introduction of asymmetric costs introduces the possibility that one group will hold a comparative advantage in indirect lobbying. In particular, if the cost of sending messages for the

[8] Direct lobbying is modelled using Grossman and Helpman's (1994) framework. Indirect lobbying influences the public who update their beliefs using a Bayesian mechanism.

environmental group is sufficiently lower, it will expend more effort in indirect lobbying and the public will believe that environmental damage is higher. This raises the bargaining power of the environmental group with the government which allows it to reduce political contributions. Thus, a substitution effect between direct and indirect lobbying is established.

Yu's (2005) paper establishes a possible explanation for the observation that environmental groups spend so little on political contributions and a large amount on 'public education'. His theory suggests that this may not be due to monetary constraints faced by environmental groups, but instead reflect some sort of comparative advantage in influencing the public. The model presented here further explores the ability of environmental groups to influence public perceptions by sending messages. For simplicity, we borrow from Yu (2005) the terminology of 'direct lobbying' to describe the making of contributions to the government and 'indirect lobbying' to imply message sending to influence public beliefs regarding damage.

We consider the case of two special interests groups, one representing environmental concerns and the other polluting interests. Each group is assumed to have perfect information regarding the actual level of environmental damage. The public, however, remains relatively uniformed. As in Yu (2005), the role of both direct and indirect lobbying is considered. There are however, several key differences. First, only the polluting interests lobby the government. Thus, we implicitly assume that for some reason, the environmental group *a priori* chooses not to make political contributions. A second difference in the modelling approaches between Yu (2005) and the current model is that while both consider the case where the costs of sending messages differ between the lobbies, this difference is imposed exogenously in Yu's model. However, it is well worth considering why the costs might be higher for one group as opposed to the other. For example, it may be that less credible messages are more costly to send. This possibility is allowed for in the present model by incorporating a cost structure which makes it more costly to send false messages. Moreover, these costs rise in the *extent* of the lie. Indirect lobbying in our model takes the form of a signalling game, where the public update their beliefs based on the credibility of the messages received. This differs from Yu (2005) where the beliefs of the public turn on the number of messages received from each lobby group. To this end, it is possible to identify separating equilibria in which the public learn the truth regarding environmental damage.

The results suggest that there are circumstances under which the public will accurately determine the level of environmental damage. If environmental damage does occur, then the public will be more likely to learn of its existence whenever the government is malevolent (values contributions highly compared with aggregate welfare), when the environmental damage is particularly severe and when the public were previously poorly informed about environmental problems. It is also shown that when profits of the firm are large, or the public itself values the production of the polluting good, they tend to be mistrustful or are unwilling to accept messages sent by the lobby representing polluting interests. A further result is that polluting interests may make contributions to the government *and* costly messages to the public. However, such strategic complementarity between these two forms of lobbying is shown to occur under very limited conditions. Finally, indirect lobbying by the environmental group is shown to have two significant effects on the lobbying efforts of polluting interests. First, polluters must pay more to influence the government by way of direct campaign contributions. Second, under certain assumptions, polluting interests will not find it optimal to engage in indirect lobbying. As such, this avenue of influence can effectively be blocked by the indirect lobbying of the environmental group.

The remainder of this paper is organized as follows. In the following section, the model structure is presented. Section 3 considers the equilibrium level of contributions offered by the firm. This is followed by a discussion of the signalling game and the possible equilibria. Section 5 considers the special case where the lower bound of damage is zero. The focus in this section is to identify the circumstances under which the public learn true environmental damage. Section 6 offers some concluding remarks and suggested directions for future research.

2 The Model

2.1 Overview

The model describes the setting of an environmental tax (*t*) in a closed economy. There are two lobby groups.[9] The first is a monopolistic producer (herein called 'the firm') of a single good, the manufacture of which involves the release of emissions that cause environmental damage. Members of this lobby group do not care about the state of the environment. The second is a group of environmentalists, called 'the greens', who are solely interested in the environmental outcomes. As such, the two lobby groups have opposing views regarding pollution and hence the appropriate level of an emissions tax. A third group, called 'the public', derive utility from the consumption of the polluting good but also care about environmental damage. The public are not politically organised.

The actual level of marginal damage (θ) is determined by nature and, for simplicity, is assumed to take on only two values: high (θ_H) or low (θ_L).[10] The true level of marginal damage is known by each of the lobby groups but not the public. Instead, the public rely on messages which may be sent by each of the lobby groups to update their *a priori* belief about environmental damage.

Figure 1 sets out a basic game tree describing the process. In the first stage, marginal damage from emissions is determined by nature. This is subsequently known by each lobby which chooses an action in order to try to influence the level of the environmental tax (t). The firm can choose one or both of the following methods. The first involves making direct contributions to the government $(S(t))$, which are contingent upon the level of the environmental tax. Contributions are made with a view to securing more lax environmental policy, hence $S'<0$. This type of lobbying (direct lobbying) is modelled following Grossman and Helpman (1994) and Fredriksson (1997). The second option for the firm is to send a costly message to the public to try and influence their belief regarding expected damage

[9] Exactly how these lobby groups form is not discussed here. For an overview of lobby group formation, see Olson (1965).

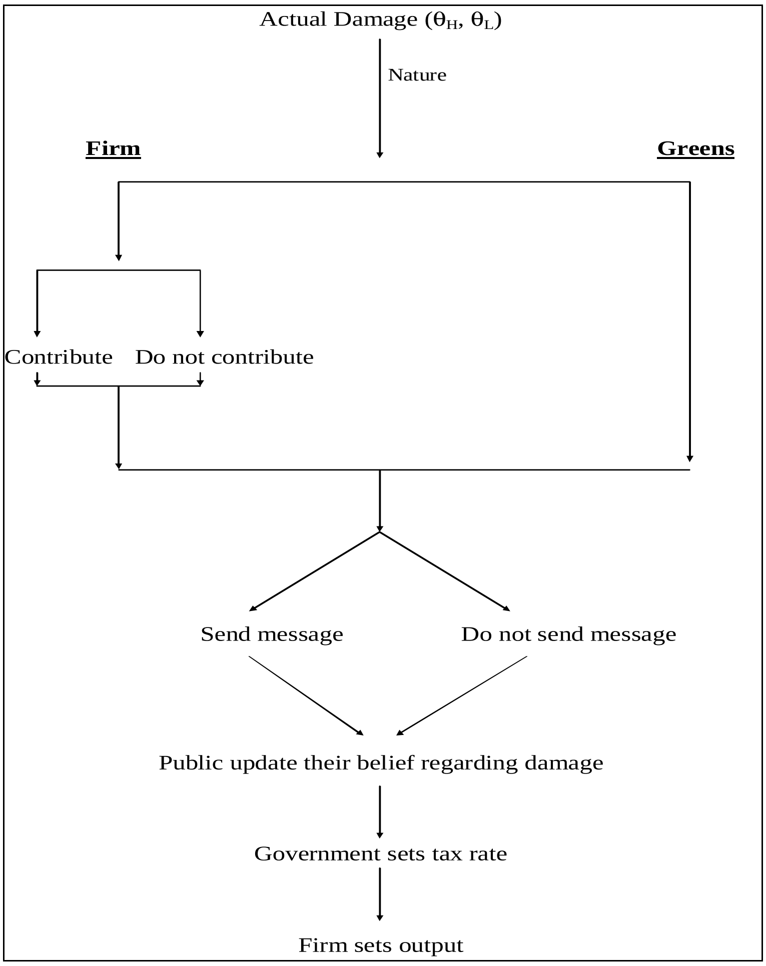
[10] This differs from Yu (2005) where the parameter measuring damage is continuous. The use of a dichotomous parameter such as in this study is common in signalling models. As will become evident, this may lead to outcomes where only one lobbying instrument is used.

(indirect lobbying). Note, the firm decides on the mix of the two strategies it will use simultaneously. By assumption, the greens do not engage in direct lobbying, but do have the option of sending a message.

Once messages are received by the public, they form a belief regarding the level of damage. The manner in which this belief is formed is discussed later in the paper. The government then sets the tax rate to maximise the sum of aggregate welfare and the contributions received from the firm. An exogenous weight determines the relative importance of each to the government. Once the tax rate is set, the firm chooses some level of output which maximises profits. The model is solved by backward induction.

Summarising, the level of the tax is dependent on contributions made by the firm and by the public's expectations regarding the level of environmental damage, which is a function of the messages they receive. This extends upon Grossman and Helpman (1994) who use a similar framework, but only consider direct lobbying.

Figure 1: Overview of the Game



2.2 Utility Functions of the Lobby Groups, The Public, and Government

We now turn to defining the utility of the agents in the model. The utility of the firm does not depend directly on the level of environmental damage. In particular, the firm does not care about the environmental damage caused, other than by its indirect influence on profits via the level of the emissions tax. Both direct and indirect lobbying impose a cost on the firm. The utility of the firm is thus specified,

$$U_F = \Pi(p) - S(t) - c(m_F \mid \theta_n) \qquad n = (H,L) \qquad (1a)$$

$\Pi(p)$ denotes gross profit from the production of the polluting good contingent on the market price (p). $S(t)$ are direct contributions made to the government in return for more favourable policy, hence $S' < 0$. $c(\cdot)$ is the cost of sending a message given the marginal environmental damage, θ_n *(n = H,L)*. Again, the subscript *n* denotes the actual level of damage as determined by nature.

The green lobby, who are assumed not to consume the good, only care about environmental damage.[11] For simplicity, environmental damage is assumed to be linear in output and equal to the product of total output $(Q(p);\quad Q' < 0)$ and the marginal level of damage (θ). The greens can also engage in sending messages to the public at a cost of $c(\cdot)$. Disutility of the greens is thus the sum of damage and these costs,

$$U_G = -\theta_n Q(p) - c(m_G \mid \theta_n) \qquad n = (H,L) \qquad (1b)$$

Note the firm and the greens are assumed to know θ_n, the actual level of marginal damage. This is in contrast to the public who are uncertain. This assumption is consistent with Olson's 'rationally ignorant voter' theorem where given the almost zero probability of having a pivotal vote, individual citizens do not

[11] As will become evident, this is a major assumption. In reality, green lobbies may have many other motives which influence their behaviour, for example, the raising of revenue from members and indeed the government. The assumption of a completely 'green minded' lobby is made for computational simplicity. Other possible motives are an avenue for future research.

find it optional to gather the required information to ascertain the level of environmental damage. On the other hand, both the greens and the firm have a larger stake in the issue and thus have an incentive to acquire the appropriate evidence. The results of this model only require that the firm and the greens have a superior knowledge of the facts surrounding environmental damage. Perfect knowledge for these groups is assumed for computational convenience. Despite their relative ignorance, it does seem reasonable to suggest that the public will have some prior notion of whether marginal damage tends towards high or low. This prior, λ, represents the *a priori* belief held by the public that marginal damage is in fact high. When the public receive a message from one or both of the lobbies, they update this belief. Let this posterior belief be denoted by $\mu = prob(\theta_H | m_G, m_F)$, where the subscripts on *m* denote a message from the greens and the firm respectively. Updating in the model follows a Bayesian mechanism, a more formal definition of which is provided later in the paper.

Thus, after receiving one or more messages, the public will form some view of the probability that damage is high. Defining this belief as

$$\theta_\mu = \mu\theta_H + (1-\mu)\theta_L$$

the utility of the public is,

$$U_P = u(x) - \theta_\mu Q(p) \tag{1c}$$

Where *u(x)* is the utility derived from consumption of the polluting good, *x*, which is approximated by consumer surplus.

Finally, the case of the government is considered. The government is assumed to maximise its political support and therefore values both political contributions and aggregate welfare $W(t)$.[12] Consistent with the approach of Grossman and Helpman (1994), the exact manner in which contributions are used by the government is not modelled. When induced by contributions to deviate from the welfare maximising policy, the government thus faces a trade off: higher

[12] Aggregate welfare, which is defined more formally later, is simply the sum of all agents utilty.

contributions versus lower aggregate welfare.[13] An exogenous weight *(β)* determines the importance of aggregate welfare relative to contributions to the government. The government's utility function is given by,

$$G(t) = S(t) + \beta W(t) \qquad \text{(1d)}$$

3 The Game

3.1 The Firm's Output and Profit

In solving the model, simple functional forms are adopted. First, the monopolist is assumed to face the following inverse demand curve, $P = a - Q$. For simplicity, the firm is also assumed to face a marginal production cost of zero. Profits are thus defined as $\Pi = (P - t)Q$. Solving the firm's first order conditions yields the familiar results,[14]

$$Q = \frac{a - t}{2} \qquad P = \frac{a + t}{2} \qquad \Pi = \frac{(a - t)^2}{4} \qquad \text{(2)}$$

3.2 The Political Equilibrium

Having derived equilibrium price, quantity and profits attention can now be turned towards the equilibrium tax rate (t^*). This section follows the menu auction model of Bernheim and Whinston (1986) which is applied to this type of problem by Grossman and Helpman (1994).

The firm offers the government contributions (S) in return for a more favourable policy outcome. As S is contingent on the tax rate chosen, which directly effects the welfare of the firm, the firm will choose S to maximise its utility in (1a). The associated first order condition is,

$$\frac{\partial U_F}{\partial S} = \frac{\partial \Pi}{\partial t}\frac{\partial t}{\partial S} - 1 = 0 \qquad \text{(3)}$$

[13] In the absence of any contributions, the government would set policy to maximise aggregate welfare. As contributions lead to less stringent policy, it follows that $W'(t) > 0$.

[14] We are concerned only with an interior solution, thus t < a is required.

Following proposition 1 in Grossman and Helpman (1994), a subgame perfect Nash equilibrium exists if :

(1) The contribution schedule is feasible,[15] and

(2) The choice of the tax rate $\left(t^*\right)$ maximises the government's welfare *(G)*, taking as given the contributions from the firm.

Lemma 2 of Bernheim and Whinston (1986) sets out the following necessary conditions in which such an equilibrium will exist:

$$t^* \in \arg\max \; G(t) = S(t) + \beta W(t) \qquad \text{(BW1)}$$

$$t^* \in \text{Arg max} \; U_F(t) + G(t) \qquad \text{(BW2)}$$

(BW1) implies the equilibrium tax rate is chosen to maximise a weighted sum of contributions and aggregate welfare while condition (BW2) requires that profits of the firm (net of contributions) and the government's welfare are jointly maximised. Using equations (1a) and (1d):

BW1: $$\frac{\partial G(t)}{\partial t} = \frac{\partial S(t)}{\partial t} + \beta \frac{\partial W(t)}{\partial t} = 0 \qquad \text{(4a)}$$

and

BW2: $$\frac{\partial U_F(t)}{\partial t} + \frac{\partial G(t)}{\partial t} = \frac{\partial \Pi(t)}{\partial t} - \frac{\partial S(t)}{\partial t} + \frac{\partial G(t)}{\partial t} = 0 \qquad \text{(4b)}$$

As (4a) and (4b) are equal,

$$\frac{\partial S(t)}{\partial t} + \beta \; \frac{\partial W(t)}{\partial t} = \frac{\partial \Pi(t)}{\partial t} - \frac{\partial S(t)}{\partial t} + \frac{\partial S(t)}{\partial t} + \beta \frac{\partial W(t)}{\partial t} \qquad \text{(4c)}$$

Which by simple rearrangement yields,

$$\frac{\partial S(t)}{\partial t} = \frac{\partial \Pi(t)}{\partial t} \qquad \text{(4d)}$$

[15] Feasible contributions are those which are non-negative and less than or equal to the lobby group's income.

This implies that around the equilibrium point, the change in contributions for a lobby group will be exactly offset by the policy induced change to that groups welfare. Grossman and Helpman (1994) coin such contributions as *locally truthful.* By substituting the right hand side of equation (4d) into the government's first order condition (4a), it becomes evident that the government will choose t^* so as to satisfy the following:

$$\frac{\partial G}{\partial t} = \frac{\partial \Pi}{\partial t} + \beta \frac{\partial W_A}{\partial t} = 0 \qquad (5a)$$

From the firms profits in (2), we obtain,

$$\frac{\partial \Pi}{\partial t} = \frac{t-a}{2} < 0 \quad ; \quad \frac{\partial^2 \Pi}{\partial t^2} = \frac{1}{2} > 0 \qquad (5b)$$

Aggregate welfare is defined as the sum of profits, environmental damage incurred by the public *($\theta_\mu Q$)* and the greens *($\theta_n Q$)*, consumer surplus $\left(\int_0^Q P(dQ) - PQ\right)$, and the cost of sending messages $\left(C(m_j \mid \theta_n), j = (F,G), n = (H,L)\right)$. Tax revenues collected are assumed not to be redistributed and thus do not appear in the specification of aggregate welfare. Aggregate welfare is thus specified,[16]

$$W_A = \int_0^Q P(dQ) - (\theta_n + \theta_\mu)\, Q - c(m_j \mid \theta_n) \qquad j = (F,G) \qquad n = (H,L) \qquad (5c)$$

Note that the greens know the true state of damage whereas the public are unsure. This implies that both θ_n and θ_μ appear in aggregate welfare.

Using (5b) and (5c), the government's first order condition (5a) is:

$$\frac{\partial G}{\partial t} = \frac{t - a}{2} + b\left(\frac{2(\theta_s + \theta_m) - a - t}{4}\right) = 0$$

[16] Notice that the weight attached by the government to damage suffered by the greens and the public is equal. This implicitly assumes a normalisation such that there is one green citizen and one public person.

solving for the equilibrium tax rate, t^*

$$t^* = \frac{\beta\left[2\left(\theta_s + \theta_\mu\right) - a\right] - 2a}{\beta - 2} \tag{6a}$$

Note that if the firm were to make no contributions, the government would set the tax so as to maximise aggregate welfare. In the absence of lobbying, the welfare maximising tax rate $\left(t^w\right)$ is equal to,

$$t^w = 2\left(\theta_n + \theta_\mu\right) - a \tag{6b}$$

The tax rate under lobbying from the firm can thus be written as

$$t^* = \frac{\beta\, t_w - 2a}{\beta - 2} \tag{6c}$$

Note the tax rate is increasing in both θ_n and θ_μ and decreasing in the parameter *a*, which is indicative of the benefits derived from consumption of the polluting good.[17,18] Thus, ceteris paribus, the tax rate will be higher when actual damage and perceived damage are higher, and lower when the value placed on production and consumption of the polluting good by society is greater. In addition, the tax is also increasing in the exogenous weight β (but at a decreasing rate). In the limit, when β approaches infinity, the tax rate approaches that of the welfare maximising rate in (6b).

3.3 Payoffs to the Lobby Groups

Before embarking on the signalling component of the model, it is useful at this stage to derive the payoffs to each of the lobby groups both when the firm contributes to the government and when it does not. Thus, for this part of the analysis, signalling is ignored.

To begin, assume that the firm does not send any signal and does not lobby. The government sets the tax rate at the welfare maximising level defined in (6b).

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[17] The requirement that t<a for positive output implies that $\theta_n + \theta_\mu < a$.

[18] Note that for very large a, (6c) can take on a negative value. In this case the firm receives a subsidy on its output.

Welfare of the firm in this situation is found by substituting the equilibrium tax rate into its profit function (2),

$$U_F\left(S=0, m=0\right)=\left(\theta_n+\theta_\mu-a\right)^2 \qquad (7)$$

Where *S=0* and *M=0* denote that the firm neither makes contributions to the government nor sends messages to the public respectively. The requirement that $\theta_n+\theta_\mu < a$ for positive output implies the welfare of the firm falls as actual and perceived damage increases across the feasible range.

Suppose now that the firm makes contributions to the government. Welfare of the firm is now the profit level under the equilibrium lobbying tax in (6a) minus its contribution. Following Grossman and Helpman, when only one lobby contributes to the government, the lobby contributes an amount which is proportional to the weighted distortion in aggregate welfare caused by its lobbying activity. This is because the lobby must compensate the government for any loss in aggregate welfare from the distortionary policy. Contributions defined in this way are expressed,

$$S_F=\beta\left[W\left(t_w\right)-W\left(t^*\right)\right] \qquad (8a)$$

Clearly, the greater the weight placed on aggregate welfare by the government or the greater the distortion in the equilibrium tax rate under lobbying, the greater are the contributions required to compensate the government.

Calculating aggregate welfare under each level of the tax and substituting into equation (8a) yields

$$S_F=2\beta\frac{\left(\theta_n-\theta_\mu-a\right)^2}{\left(\beta-2\right)^2} \qquad (8b)$$

Note that the level of contributions is always positive and thus an interior solution always exists. Further, $S'\left(\beta\right)<0$ and $S''\left(\beta\right)>0$. Intuitively, as the government increases the weight on aggregate welfare relative to contributions, it values welfare more highly and consequently, the marginal compensation required to change policy increases. Further, examination of equation (5b) reveals that

$\Pi'(t) < 0, \quad \Pi''(t) > 0$. Thus, as the government becomes more benevolent, environmental stringency increases, resulting in lower firm profits. As profits are decreasing and convex in the rate of tax, the firm has a diminishing marginal return from policy concessions when the tax is relatively high. Nonetheless, as shown in equation (8b), contributions are always positive. The intuition behind this result can be clarified by calculating the utility of the firm when it lobbies directly (net of contributions), which is,

$$U_F\left(S_F > 0, m = 0\right) = \frac{\beta\ \left(\theta_n + \theta_\mu - a\right)^2}{\beta - 2} \tag{9a}$$

By comparing this to equation (7), it is evident that that the firm will do better by lobbying directly to the government for any $\beta > 2$.[19] The intuition behind this is that only when β approaches infinity does the tax rate approach the welfare maximising level. Consistent with this idea, note that (7) and (9a) are equivalent when β approaches infinity. Thus, only when the government cares only about aggregate welfare of its citizens will the firm cease to make contributions.

The disutility of the green lobby is easily derived by calculating the firms profit maximising level of output when $t = t^*$ and substituting this back into the utility function in (1b).

$$U_G\left(m = 0\right) = \frac{\beta\theta_n\left(\theta_n + \theta_\mu - a\right)}{\beta - 2} < 0 \tag{9b}$$

Note that unlike the firm, welfare of the greens increases with the weight on aggregate welfare ascribed by the government. This reflects increases in the stringency in environmental policy under a more benevolent government, resulting in lower environmental damage.

[19] For the remainder of this paper it is assumed that β is greater than 2 implying that the firm always does better by lobbying.

4 Signalling

4.1 Background

Signalling in the model takes the form of messages regarding the level of damage which are sent by each lobby group. The intuition behind the signalling game is similar to that of Spence (1973).[20]

To begin the discussion, and to ensure that the motivation of the players is made clear, examine the equilibrium lobbying tax rate (equation 6a).

$$t^* = \frac{\beta\left[2\left(\theta_n + \theta_\mu\right) - a\right] - 2a}{\beta - 2} \qquad \text{(6a)}$$

Recall the expected level of damage of the public is defined as,

$$\theta_\mu = \mu\theta_H - (1-\mu)\theta_L$$

Where μ is the probability assigned to high damage by the public after they have received messages from the lobby groups. Note that from (6a),

$$\frac{\partial t^*}{\partial \theta_\mu} = \frac{2\beta}{\beta - 2} > 0 \qquad \forall \beta > 2 \qquad \text{(9c)}$$

The tax rate is increasing in the level of damage the public believe will occur and implies that the lobby groups have an incentive in trying to manipulate the level of expected damage for this group.

Lemma 1.

No matter what the level of actual damage, the firm will never wish to send a message that damage is high (θ_H) and the greens will never wish to send a message that damage is low(θ_L).

Proof Taking the derivative of the welfare functions of the firm and the greens with respect to (θ_μ) yields,

[20] For a concise overview of the Spence model, see Mas-Colell et al (1995) pp 450-460.

$$\frac{\partial U_G}{\partial \theta_\mu} = \theta_n \frac{\beta}{\beta - 2} > 0 \quad (10a)$$

$$\frac{\partial U^f}{\partial \theta_\mu} = \frac{2\beta(\theta_n + \theta_\mu - a)}{\beta - 2} < 0 \quad (10b)$$

This implies when sending a message, the strategies are $m_G = \theta_L$ and $m_F = \theta_H$ are never optimal. The firm always prefers a lower tax rate and will thus act in a manner which it hopes will achieve this. Whenever environmental damage occurs, the opposite is true for the greens.

We consider Perfect Bayesian Equilibria (PBE). Following Mas-Colell *et al* (1995, p452), we can state the conditions under which the public's belief (μ) after observing the messages of the lobby groups is a PBE:

C1: The sender's strategies are optimal given the strategy of the public.

C2: The posterior belief function, $\mu(\theta_H \mid m_j), j=g,f$ is derived from the senders' signals using Bayes Law.

Bayesian updating in the model takes the following form,

$$prob(\theta_H \mid \{m_G, m_F\}) = \mu = \frac{prob(\{m_G, m_F\} \mid \theta_H)\lambda}{prob\ (\{m_G, m_F\} \mid \theta_H)\lambda + prob(\{m_G, m_F\} \mid \theta_L)(1\text{-}\lambda)} \quad (11)$$

Where again, λ is the *a priori* belief held by the public regarding marginal environmental damage.

4.2 Separating and Pooling Equilibria

We consider two types of equilibria: pooling and separating. In a pooling equilibrium, the public are unable to derive any new information from the messages which are sent by the lobbies and thus remain uncertain regarding the level of actual damage. This occurs when, given values of the exogenous parameters, a given message set will be sent in either state of damage. Formally, for any set of messages $\{m_G, m_F\}$ where $prob(\{m_G, m_F\} \mid \theta_H) = prob(\{m_G, m_F\} \mid \theta_L)$, by Bayes' rule (equation 11), it must be that $\mu = \lambda$.

In a separating equilibrium the public learn the truth regarding environmental damage. This implies that the solution for μ must be either zero or unity. To see this, consider the following candidate separating equilibrium where the public correctly infer that damage is high after receiving a set of messages $\{m_G, m_F\}$ (i.e. $\mu = 1$). Examination of equation 11 reveals that this can only occur if the public believe that the message set observed will never be sent when damage is low. Formally, a separating equilibrium requires:

$$\Pr(\theta_n \mid m_j) = 1 \textit{ and } \Pr(\theta_{-n} \mid m_j) = 0 \qquad n = (H, L) \; ; \; j = (F, G))$$

and –n denotes ‘not state n’.

Turning our attention back to the equilibrium tax rate we can thus see the effect of each. In a pooling equilibrium, let $\mu = \lambda$ and

$$\theta_\mu = \lambda\theta_H + (1-\lambda)\theta_L \equiv \theta_\lambda$$

and in a separating equilibrium,

$$\theta_\mu = \theta_H \text{ if } \mu = 1$$
or
$$\theta_\mu = \theta_L \text{ if } \mu = 0$$

4.3 Cost of Sending Messages

Before examining the payoff functions under both direct lobbying and signalling, we need to explicitly define the costs of sending a message. In this model, costs take the form,

$$c(m_j \mid \theta_n) = 1 + |m_j - \theta_n| \qquad j = (F,G) \qquad n = (H,L) \qquad (12)$$

This implies that the cost of sending a message consistent with the actual state of damage is equal to unity. On the other hand, a lobby group wishing to send a message which is false faces higher costs, which are increasing when the divergence from the true state is greater. As noted earlier, this extends upon Yu (2005) where the costs of sending messages are not a function of parameters of the model.

In a real world context, specification of costs in this manner can be justified on several grounds. While the nature of the message is not considered in the model, if we assume that a message regarding environmental damage requires some scientific evidence, it is reasonable to assume that the search costs associated with finding supporting evidence when the message is untruthful might be higher. For example, the sender may have to fund research to back their position.[21] It is also likely that public will be harder to convince when there is less available evidence. Thus, greater expenditure may be required in order to generate a persuasive message.[22] Finally, it is likely that the potential costs of the truth being uncovered in some future period might be large for a lobby group who previously sent messages which were false. For example, the group's credibility in future environmental debates may be damaged or it may be subject to litigation. This type of discovery in future periods is beyond the scope of this model, however still warrants consideration in the specification of costs.

5 Results

5.1 Identifying Possible Equilibria

Attention is now directed to identifying equilibria in the model. For computational convenience, and to minimise the need for numerical simulations, the assumption is made that $\theta_L = 0$. This implies that the polluting activity either causes environmental damage of θ_H or is completely innocuous and causes no environmental degradation. Such an assumption fits quite well with recent debates surrounding global warming. For example, despite being in a minority, some scientists argue that the *effective* damage of greenhouse gas emissions on human

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[21] An example of this is that of the tobacco industry which often employed their own researchers to refute the claims of outside parties regarding the damage caused by smoking. For example, Glantz *et al.* (1996, p337) estimate that more than $US20 million was spent on research by tobacco interests from 1972-91. Much of this research, it is argued, was not peer reviewed and was used specifically to sway the views of the public.

[22] As an anecdotal example, *PR Watch* cite a Los Angeles Times article which reveals that in 1997 the *Global Climate Coalition*, an group representing polluting interests spent $US13 million on its anti-Kyoto campaign, which was designed to try and refute increasing scientific evidence of the deleterious effects of global warming. It is noted that this was greater than the entire Greenpeace budget over the same period. For details see: http://www.prwatch.org/improp/gcc.html (accessed 22/3/04).

activities is zero.[23] This is equivalent in the context of the model presented here of assuming the lower bound on damage to be zero. For future reference, note that $\theta_L = 0$ and $\theta_\mu = \mu\theta_H$.

5.2 Messages from the Green Lobby

Under what circumstances will the public uncover the truth regarding environmental damage from messages sent by each of the lobbies? In order to answer this question, we need to consider what may occur in either state of damage. To begin, let us first consider the actions of the green group when damage is low (zero). It turns out that the greens will never send a message when damage is low. Incorporating signalling costs into equation and using (9b), it is evident why this is so

$$U_G\left(m=\theta_H\right)=\frac{\beta\theta_n\left(\theta_n+\mu\theta_H-a\right)}{\beta-2}-\left(1+\theta_H\right) \qquad n=\left(H,L\right)$$

where $\left(1+\theta_H\right)$ are the costs associated with sending a message to the public and $\frac{\beta\theta_n\left(\cdot\right)}{\beta-2}$ is the disutility caused by the polluting good.

Recall from Lemma 1, the greens will only ever send a message claiming that damage is high. However, as this group cares only about environmental damage, when there is no damage, they suffer no disutility. It follows that they can gain nothing from influencing public beliefs when $\theta_n = 0$, and thus would never incur the costs $\left(1+\theta_H\right)$ associated with sending a message when damage is low. Thus,

Lemma 2

When the greens send a message that damage is high, the public will always correctly infer that damage is in fact high.

Proof: The proof of Lemma 2 is undertaken in two parts.

[23] For a numerous examples of this type of argument, see http://www.globalclimate.org/opinion/scientists.htm.

i. When marginal damage is low (zero), disutility of the green lobby falls to zero when it does not send a message $\left(\left(U_G \mid m_G = 0\right) = 0\right)$. If the greens send a message in these circumstances, they incur signalling costs. Thus, $\left(\left(U_G \mid m_G = \theta_H\right) = -\left(1 + \theta_H\right)\right)$. Given this, the greens will clearly be better off by not sending a message.

ii. The public have a knowledge of all exogenous parameters of the problem other than the true state of environmental damage. They are thus aware that if the true marginal rate of damage is low, the green lobby will never find it optimal to send a message. It follows that if the public observe a message from the greens, then they must believe that they are in the high damage state.

Lemma 3

If the greens send a message stating that damage is high, it is never optimal for the firm to counter this message with a claim of low damage.

Proof: Suppose this is not the case and the firm counters the green's claim of high damage with a low damage message. By Lemma 2 the public still believe damage to be high. Thus, the firm's welfare is lower when it sends a message than if it had not done so. Specifically, by sending a message the firm violates condition 1 of a PBE which states that the senders strategy must be optimal given the beliefs of the public. Intuitively, the firm has no capacity to influence the public and will not incur any costs in attempting to do so.

Taken together, Lemmas 2 and 3 imply the existence of a candidate separating equilibrium in the high damage state where the public receive a message from the greens, no message from the firm, and correctly infer the true level of damage. To prove the existence of this equilibrium, it remains to show that there exist some circumstances where it is optimal for the greens to send a message. This can be examined by comparing the difference in green payoffs between sending a message and not (when the actual level of marginal damage is high). Assume that in the case where the greens do not send a message, the posterior belief regarding marginal environmental damage is equal to μ, $\mu < 1$.[24] Using (9b), disutility suffered by the greens is:

$$U_G\left(m=0\right)=\frac{\beta\theta_H\left(\theta_H+\mu\theta_H-a\right)}{\beta-2} \qquad (13a)$$

Alternatively, the greens can send a message and incur a cost of unity. As per lemma 2, this will imply a posterior belief of $\mu = 1$. Disutility will thus be:

$$U_G\left(m=\theta_H\right)=\frac{\beta\theta_H\left(2\theta_H-a\right)}{\beta-2}-1 \qquad (13b)$$

defining $\Omega^G = U^G\left(m=\theta_H\right)-U^G\left(m=0\right)$, we can derive the change in disutility associated with sending a message for the greens. Subtracting (13a) from (13b) yields,

$$\Omega^G=\frac{\beta\left(\theta_H^2-\mu\theta_H^2-1\right)+2}{\beta-2} \qquad (13c)$$

For all $\Omega^G > 0$, the greens find it optimal to send and thus a separating equilibrium exists. This obviously depends on the relative values of θ_H, μ, and β. Numerical examples are provided in Appendix 1 which reveals that message sending by the greens may be optimal, however, there are situations where even though the public will believe them, the greens do not find it worthwhile to send their ‘high damage’ message. The overall characteristics of this equilibrium are detailed in the following proposition.

Proposition 1

(*a*) *In the high damage state, a separating equilibrium exists:* $\{m_G, m_F\} = \{\theta_H, 0\}$ *and,*

[24] Clearly, if this were not the case it would never be optimal for the greens to send a message. Note that the conditions of a PBE impose no restrictions over off-equilibrium beliefs. For a discussion of this, see Gibbons (1992).

$$prob\left(\theta_H \mid \{m_G, m_F\} = \{\theta_H, 0\}\right) = \mu = \frac{prob\left(\{m_G, m_F\} = \{\theta_H, 0\} \mid \theta_H\right)\lambda}{prob\left(\{m_G, m_F\} = \{\theta_H, 0\} \mid \theta_H\right)\lambda + prob\left(\{m_G, m_F\} = \{\theta_H, 0\} \mid \theta_L\right)(1\text{-}\lambda)} = 1$$

(b) The likelihood of this equilibrium

i. Decreases with the weight attached to aggregate welfare by the government (β).

ii. Decreases with the publics' (out of equilibrium) posterior belief (μ).

iii. Increases with the level of marginal environmental damage (θ_H).

Proof: (a) The equilibrium satisfies both properties of a PBE. Together, Lemmas 2 and 3 imply that:

$prob\left(\{m_G, m_F\} = \{\theta_H, 0\} \mid \theta_L\right)(1\text{-}\lambda) = 0$, and thus by Bayes rule, the posterior probability of the public is given as:

$$prob\left(\theta_H \mid \{m_G, m_F\} = \{\theta_H, 0\}\right) = \mu = \frac{prob\left(\{m_G, m_F\} = \{\theta_H, 0\} \mid \theta_H\right)\lambda}{prob\left(\{m_G, m_F\} = \{\theta_H, 0\} \mid \theta_H\right)\lambda} = 1 \qquad \forall prob\left(m_G = \theta_H\right) > 0$$

Appendix 1 provides numerical simulations which indicate situations where the greens send a message and the equilibrium is sustained.

(b) Direct differentiation of (13c) yields:

$$\frac{\partial \Omega^G}{\partial \beta} = \frac{-2\theta_H^2(1-\mu)}{(\beta-2)^2} < 0 \tag{14a}$$

$$\frac{\partial \Omega^G}{\partial \mu} = \frac{-\beta\theta_H^2}{(\beta-2)} < 0 \qquad \forall(\beta-2) > 0 \tag{14b}$$

$$\frac{\partial \Omega^G}{\partial \theta_H} = \frac{2\beta\theta_H(1-\mu)}{(\beta-2)} > 0 \qquad \forall(\beta-2) > 0 \tag{14c}$$

The intuition for each result is as follows. When the government attaches a high weight to aggregate welfare relative to contributions, the emissions tax is set closer to the welfare maximising rate. This decreases output and subsequent environmental damage, reducing the incentive of the greens to incur costs in sending a message.

Equation (14b) reveals the importance of the publics' off equilibrium beliefs. The motivation of the greens in sending a message is clearly to alter the beliefs of the public. In the event that the public would otherwise believe that damage is relatively high even when the greens do not send, the potential gain of sending a message is lower. Conversely, where the public are sceptical about environmental damage, the gains from sending a message are larger.

When environmental damage is greater, the green lobby's members suffer greater disutility from the firm's production. As such, they stand to gain substantially from more stringent environmental policy. This policy, as shown by (9c), becomes more stringent in the publics' awareness of environmental damage. The incentive to educate the public thus rises when the activities of the firm severely damage the environment.

Finally, note that the green lobby does not consume the polluting good, nor does it capture any profits which arise from production. As such, its sending strategy is independent of the value society places on the good.

It is also instructive to consider the case where the actual state of environmental damage is low. In this situation, it is possible that the public will learn this fact, even when no messages are sent. Specifically,

Corollary 1

If, for given exogenous parameters, it is optimal for the firm to send a message when damage is high, if the public observe the message set $\{0,0\}$*, Bayes' Law implies that they must correctly infer that damage is low. Thus,*

Proposition 2

A separating equilibrium exists such that when the public observe a message set of $\{0,0\}$*, they believe that damage is low* $(\mu = 0)$

Proof: Proposition 1 details conditions under which the green lobby will send a message and thus the public will believe that damage is high. If conditions are such that the greens find it worthwhile to send a message when damage is high, the public must interpret the message set $\{0,0\}$ to imply that they are in the low damage state. Not to do so would violate condition 2 of a PBE.[25] Note also that this equilibrium is characterised by the firm not sending a message. Obviously, given the equilibrium beliefs, it will never be optimal for the firm to send a message claiming damage is low. To do so would incur costs for the firm even though it is impossible to lower the publics' belief any further.

This equilibrium is indicative of the fact that, under certain circumstances, the public look to the greens for information regarding environmental damage. As the greens are always believed, their silence also conveys information to the public. For example, suppose the public know that the upper bound of damage is very high. While they are uncertain as to which state they are in (high or low damage), they are aware that were the activities of the firm really causing damage as per the worst case scenario, the green lobby, which has perfect information, would be outspoken. As such, they are able to correctly identify that they are in the low damage state provided the greens say nothing.

5.3 Messages from the Firm

Numerical simulations provided in the Appendix 1, show that despite the fact that they will always be believed by the public, it is sometimes not optimal for the greens to send a message. These cases are highlighted by part (b) of Proposition 1. When the greens *do not send*, it follows that their remain two possible message sets: (i) neither party sends a message $\left(\{m_G, m_F\} = \{0,0\}\right)$, and (ii) Only the firm sends a message $\{m_G, m_F\} = \{0, \theta_L\}$. Note, however, that both of these message sets may be feasible in either state of damage.[26] Before describing these equilibria, it is instructive to first consider the general incentives facing the firm when it chooses between sending and not sending a message (given the strategy of the greens).

In either state, define the beliefs of the public as $\bar{\mu}$ when the firm does not send a message and $\tilde{\mu}$ when the firm sends a message claiming that damage is low.

[25] This is contingent on it being optimal for the greens to send when damage is high. There are, as will be shown, occasions where this is not the case and other equilibria are thus possible.

[26] Note that under the conditions where Proposition 2 holds, namely that the greens find it optimal to send in the high damage state, the latter message set is not feasible. However, in cases where, even if damage were high, the greens do not send, it is feasible that the firm would send a message in the low damage state.

Note that the firm will only find it optimal to send a message if it causes the public to believe damage is lower than it would have if no message had been sent. *Ceteris paribus* , it follows that $\bar{\mu} > \tilde{\mu}$.[27] Using (9a), the firms welfare after sending a message is,

$$U_F\left(m=\theta_L\right)=\frac{\beta\ \left(\theta_n+\tilde{\mu}\theta_H-a\right)^2}{\beta-2}-\left(1+\left|m_F-\theta_n\right|\right) \qquad n=\left(H,L\right) \qquad (15a)$$

If it does not send a message, it will save incurring a cost, but the public will adopt a belief of $\bar{\mu}$. The welfare of the firm will thus be:

$$U_F\left(m=0\right)=\frac{\beta\ \left(\theta_n+\bar{\mu}\theta_H-a\right)^2}{\beta-2} \qquad n=\left(H,L\right) \qquad (15b)$$

Subtracting (15b) from (15a) yields the payoffs from sending for the firm, defined as Ω^F. This will obviously differ depending on the true state of nature:

High damage:

$$\Omega^F=\frac{\beta\ \left(\theta_H+\tilde{\mu}\theta_H-a\right)^2}{\beta-2}-\frac{\beta\ \left(\theta_H+\bar{\mu}\theta_H-a\right)^2}{\beta-2}-\left(1+\theta_H\right) \qquad (15c)$$

Low damage:

$$\Omega^F=\frac{\beta\ \left(\tilde{\mu}\theta_H-a\right)^2}{\beta-2}-\frac{\beta\ \left(\bar{\mu}\theta_H-a\right)^2}{\beta-2}-1 \qquad when\ \theta_L=0 \qquad (15d)$$

Again, $\Omega^F>0$ is a necessary condition for the firm to send a message. We begin by examining when this is likely to occur. The results are summarised in the following proposition:

Proposition 3

Given a strategy of not sending by the Greens, the likelihood of the firm sending a message is:

[27] Nothing in the conditions for a PBE restrict beliefs in this manner. Essentially, this assumption is made as an equilibrium refinement in order to reduce the number of possible equilibria.

i. *More likely when the weight attached to aggregate welfare by the government (β) is low*

ii. *Ambiguous in the upper bound of marginal environmental damage (θ_H).*

iii. *More likely when the message is sufficiently persuasive $(low\ \tilde{\mu})$.*

iv. *More likely when the public have a predisposition to believe damage to be high $(high\ \bar{\mu})$.*

v. *More likely when the returns from production and consumption (a) are large*

Proof: The results (i) through (v) are obtained by direct differentiation of equation (15c).[28] Each is discussed in turn below.

i. $$\frac{\partial \Omega^F}{\partial \beta} = 2\theta_H\left(\tilde{\mu} - \bar{\mu}\right)\frac{\left(2a - 2\theta_H - \tilde{\mu}\theta_H + \bar{\mu}\theta_H\right)}{\left(\beta - 2\right)^2} < 0 \qquad (16a)$$

The sign is contingent on the assumption that $\bar{\mu} > \tilde{\mu}$, and that for positive output, $a > \theta_n + \theta_\mu$, where $\theta_\mu = \mu\theta_H$ when $\theta_L = 0$.[29] The implication is that the firm is more likely to send a message when the government places a low weight on aggregate welfare. This result may seem counter-intuitive when one considers that under these circumstances, the government tends to ignore the wishes of the public. As such, the beliefs of the public become more irrelevant. However, when the government is responsive to political contributions made by the firm, the productivity of these contributions is high, resulting in lax policy. This puts the firm in a position where it stands to lose more from any change in policy.[30] Even though the government is not overly responsive to public perceptions regarding damage, the firm still finds that it is worthwhile to protect its position.[31] This implies that to some extent, direct and indirect lobbying are strategic complements for the firm. Note that taken together with Proposition (1b), which shows that the

[28] The signs are unchanged using equation (15d), with the exception of the effects of the upper bound of damage. This is discussed in what follows.

[29] In this situation this posterior belief is given by *either* $\bar{\mu}$ or $\tilde{\mu}$.

[30] Consistent with this, note that by equation (9a), the firm's utility is falling in β ($\forall\beta$>2).

[31] Note of course that as per lemma 3, the firm will never find it optimal to send when the greens have sent a message.

greens face stronger incentives to lobby when government is less responsive to aggregate welfare, it is shown that indirect lobbying is more likely when the government does not care. This seemingly counter intuitive result may well be explained by the fact that the need for indirect lobbying only arises from government failure in the first place. In the event that government is completely benevolent (and incorruptible), there is no need for the public to be informed.

ii. To examine the effects of the upper bound of damage on the payoffs from sending a message, we need to consider both the high and low damage state. We consider the latter first. Differentiation of (15d) yields

$$\frac{\partial \Omega^F}{\partial \theta_H} = \frac{-2\beta}{(\beta-2)}(\bar{\mu}-\tilde{\mu})(\bar{\mu}\theta_H+\tilde{\mu}\theta_H-a)>0 \qquad (16b)$$

Where the sign turns upon the afore mentioned assumptions regarding beliefs $(\bar{\mu}>\tilde{\mu})$, and the conditions for positive output. Intuitively, in the low damage state, the firm is able to send a truthful message by incurring a cost of unity. The parameter θ_H represents the 'worst case' scenario for the public. Thus, when this upper bound on damage is very large, the firm stands to gain more from convincing the public that they are closer to the low damage state. Hence, it is more likely that the firm will send a message.

In the high damage state, the costs to the firm of sending a (false) message are higher and this complicates its strategy. This can be seen by differentiation of equation 15(c), which yields:

$$\frac{\partial \Omega^F}{\partial \theta_H} = \frac{2\beta}{(\beta-2)}\left[a(\bar{\mu}-\tilde{\mu})+\theta_H\left(2(\tilde{\mu}-\bar{\mu})+(\tilde{\mu}^2-\bar{\mu}^2)\right)\right]-1 \gtrless 0 \qquad (16c)$$

There are two major components of (16c). The first term in parenthesis, $a(\bar{\mu}-\tilde{\mu})$ represents the gains which accrue to the firm from influencing public perceptions regarding damage. As $\bar{\mu}>\tilde{\mu}$, this term is unambiguously positive. The second term, $\theta_H\left(2(\tilde{\mu}-\bar{\mu})+(\tilde{\mu}^2-\bar{\mu}^2)\right)<0$ represents the costs involved with making a false claim regarding damage in order to influence the public. Thus, when the first of these terms is sufficiently large, (16c) is positive. In this case, the gains from influencing the public will outweigh the costs of doing so, and the firm will have an incentive to lie. Note that when the parameter a is large, the stakes will be higher for the firm and this result is more likely. Conversely, when the second effect dominates, the firm will be less likely to send. Intuitively, if the gains from persuading the public are small, but the costs associated with doing so are large, it cannot be optimal for the firm to send a message. Importantly, note that this is more likely as the upper bound of damage (θ_H) increases.

iii. $$\frac{\partial \Omega^F}{\partial \tilde{\mu}} = \frac{2\beta(\theta_H + \tilde{\mu}\theta_H - a)}{\beta - 2} < 0 \qquad (16d)$$

$\tilde{\mu}$ is the posterior belief of the public after receiving a low damage message. As such, it is a measure of how well the firm does in influencing beliefs. When $\tilde{\mu}$ is high, it implies that the public believe damage is large even when the firm tries to convince them otherwise. Conversely, the gains from sending a message which accrue to the firm are greater when their message influences the public to a greater extent.

iv. $$\frac{\partial \Omega^F}{\partial \bar{\mu}} = \frac{-2\beta(\theta_H + \bar{\mu}\theta_H - a)}{\beta - 2} > 0 \qquad (16e)$$

When the firm does not send a message, the public assign a posterior probability of $\bar{\mu}$ of damage being high. Where this is high, the firm will stand to lose from the more stringent policy which follows. It thus stands to gain by convincing the public that damage is lower. Note that this effect is strong when the government attaches a high weight to aggregate welfare.

v. $$\frac{\partial \Omega^F}{\partial a} = \frac{2\beta(\bar{\mu} - \tilde{\mu})}{\beta - 2} > 0 \qquad (16f)$$

Finally, the payoffs associated with sending a message for the firm are shown to be increasing in a. Recall that this parameter reflects the gains which accrue to the firm from the production of the good. Intuitively, when the rewards from production are high, so too are the consequences of environmental policy. Hence, the firm acts to protect its position by sending a message in an effort to sway public opinion regarding the environmental effects of its activities. Note that this effect is greater when the firm's message is influential $\left((\bar{\mu}-\tilde{\mu})\text{ is large}\right)$.

5.4 *Learning from the Firm's Messages*

As noted, there are two possible message sets received by the public when the greens do not send: $\left(\{m_G, m_F\}=\{0,0\}\right)$ and $\left(\{m_G, m_F\}=\{0,\theta_L\}\right)$. To identify the nature of these equilibria, it is necessary to consider the possible beliefs of the public. We begin by examining the second of the possibilities, where the firm sends a low damage message and the greens do not send.

Upon receipt of $\left(\{m_G, m_F\}=\{0,\theta_L\}\right)$, let us assume that there are three possible beliefs: $\mu=1$; $\mu=0$; $\mu=\tilde{\mu}$. The first possibility, that the public believe themselves to be in the high state, would clearly violate condition 1 of a PBE. In particular, were this to be the case, the firm would not bother to incur the costs of sending a message (as the beliefs could not be higher if they did not send). This equilibrium is thus not a feasible one.

Suppose on the other hand, that for some values of the exogenous parameters, the firm were always to send in both states. In this case, the equilibrium would be characterised by $\left(\{m_G, m_F\}=\{0,\theta_L\}, \mu=\tilde{\mu}\right)$ where $\tilde{\mu}=\lambda$, the publics' prior belief. Intuitively, if conditions are such that the firm would send in either state, it is impossible for the public to learn anything from its messages. The proof of this equilibrium is detailed as follows:

Lemma 4

For any set of beliefs $\{\tilde{\mu},\bar{\mu}\}$, where $\bar{\mu}>\tilde{\mu}$, if the firm finds it optimal to send a message to the public when damage is high, it will also send when damage is low.

Proof: Subtracting (15d) from (15c) yields,

$$\left(\Omega^F \mid \theta_H\right)-\left(\Omega^F \mid \theta_L\right)=\frac{\theta_H\left[2\beta\theta_H\left(\tilde{\mu}-\bar{\mu}\right)\right]}{(\beta-2)}-\theta_H<0 \qquad \forall \tilde{\mu}\le\bar{\mu} \tag{17}$$

The negative sign on equation (17) confirms that given parameter values, payoffs from sending a message are always greater in the low damage state. Thus,

Proposition 4

Where the greens do not find it profitable to send a message to the public, and the firm finds it optimal to send a message when damage is high, it will also always send if damage is low. The public can then learn nothing from the messages of the firm and will not update their beliefs. Thus, $\left(\{m_G, m_F\} = \{0, \theta_L\}, \mu = \tilde{\mu} : \tilde{\mu} = \lambda\right)$

Note the conditions under which this equilibrium is possible. First, it must not be optimal for the greens to send, as their message is always believed. Second, the firm must, given the strategy of the greens, find that when damage is high, it is optimal to send a message. Numerical simulations which appear in the appendices 2 and 3 consider these possibilities. There are many possible numerical values which can be placed on the parameters and the purpose of the simulations is solely to demonstrate the possible existence of this type of equilibrium. It is shown that this is most likely when the upper bound of environmental damage is low (i.e. a lower value on θ_H) and the profits of the firm are large. Intuitively, the public know that when profits are large, the firm has a stronger incentive to send a false message in order to protect its position. It follows that given this knowledge, the public will not consider the message to be credible.

Lemma 4, which shows that the firm always does better by sending when damage is low, suggests that there may be an equilibrium in which the firm sends a message only in the low damage state. By Bayes' rule, if the public only observe a message from the firm when damage is low, they must correctly infer the true state of damage from this message. If it is optimal for the firm to send a message when its activities do not cause environmental damage $(\theta_n = \theta_L)$, it follows that if the public observe no message from the firm, they must believe themselves to be in the high damage state. Thus,

Proposition 5:

For relevant values of the exogenous parameters, if the greens do not send a message and the firm only sends when damage is low:

i. *If the public observe a message from the firm, they believe themselves to be in the low damage state* $\left(\{m_G, m_F\} = \{0, \theta_L\}, \mu = 0\right)$.

ii. *If the public observe no message, they will believe damage to be high* $\left(\{m_G, m_F\} = \{0,0\},\ \mu = 1\right)$.

This equilibrium is characterised by the public believing the firm when it sends a message, but inferring damage is high when it does not. Simulations in the Appendix 1 show this tends to occur when the upper bound of damage is high and profits are low. Specifically, if profits are sufficient to make it worthwhile to send a (less costly) truthful message, but are not large enough to justify the expenses associated with making a false claim, the public are able to believe the firm.

A final possibility is that both lobby groups fail to send a message in either state. Again, Bayes' law requires that the public are unable to infer anything from the sending strategies of the firm and the greens. By Propositions 1 and 3, one case where this is likely to occur is when the weight attached to aggregate welfare (β) is high and profits are low. In such cases, both lobbies are less likely to send. Intuitively, when the government is responsive to the needs of citizens, environmental policy will be set closer to the welfare maximising level. The greens will thus have less cause to influence the public. At the same time, if the returns from production of the polluting good are low, then the firm stands to gain little from changing the public's belief. In this case, the public will remain ignorant about the true level of environmental damage. This is shown to only occur when the level of marginal damage is exceedingly small. Intuitively, if damage is a non-issue, few gains will accrue to either lobby from engaging in indirect lobbying.

5 Conclusion

Empirical evidence suggests that lobby groups representing environmental interests are far less likely to make political contributions to politicians. This raises the question, how is it that these groups are able to influence public policy? One possibility is that this is achieved by influencing public opinion. This type of indirect lobbying indeed appears to be a major strategy of most environmental groups.

Building on Yu (2005), this paper examines direct and indirect lobbying in a model where opposing special interest groups representing a polluting industry and environmental concerns vie over the stringency of environmental policy outcomes.

The environmental lobby wishes to minimise environmental damage and thus seeks to raise awareness of an uncertain public regarding the damaging effects of the firm's production. As the government pays attention to these beliefs in deciding policy, raising public awareness of environmental damage leads to more stringent policy outcomes. At the same time, the firm, who wishes to minimise the effects of policy, may also try and influence the public. In addition, it can also make direct political contributions, a process modelled as per Grossman and Helpman (1994).

The results of this model yield some interesting results. There are assumed to be two possible states of environmental damage. The production process either causes some level of environmental damage or it does not. Given this assumption, messages sent by the green lobby are always believed by the public. In these circumstances, it is clearly not in the interests of the firm to engage in indirect lobbying. This reveals a picture of the lobbying process which seems to fit well with the observed behaviour of polluting and environmental interests. Importantly, however, the green lobby will not always find it optimal to inform the public. This may occur when the government is responsive to the welfare of its citizens relative to political contributions. As the government is aware of the truth regarding environmental damage, it will thus set policy accordingly. In addition, if environmental damage is not significant, the green group will be less prone to incur the costs of informing the public.

Situations where the greens do not send messages lead to the possibility of the firm making an attempt to mislead the public. A particularly important result is that when the firm's profits are sufficiently large, the incentives to mislead increase. The public, aware of the incentives facing the firm, are less likely to believe these messages. Conversely, when profits are low, the public will be more likely to take the messages from the firm at face value.

It is also found that when the government is responsive to political contributions, the firm will face stronger incentives to engage direct and indirect lobbying. In this situation, the high marginal productivity of campaign contributions increase the profits of the firm. It is thus protective of these larger returns and thus stands to gain more by influencing the public. Direct and indirect lobbying by the firm thus seem to some extent to be strategic complements. However, given the same circumstances, the green lobby also has a higher propensity to engage in indirect lobbying. This has several strategic benefits for the greens. First, by nature of the equilibria in the model, their messages are always believed. As such, the firm will not find it optimal to send a message when the greens have done so. Thus, a message sent by the greens has the effect of blocking the firms avenue of lobbying indirectly. A further benefit of this strategy is that as contributions must compensate the government for the political costs of adopting weaker policy, raising public awareness decreases the effectiveness of direct lobbying by the firm. Overall, it may appear to be counter-intuitive that the incentives to engage in indirect lobbying rise with government apathy towards the beliefs of the public. The intuition, however, is one of strategy. The firm is keen to protect its strong position, while the greens, who have the advantage of always sending credible messages can block the firm from influencing the public and simultaneously raise the costs associated with direct lobbying.

This model is an introductory step to explaining a phenomenon which has to a large extent been ignored by the economic literature. As such, several extensions are warranted. A first and obvious extension is to allow the green lobby to make direct contributions to the government in the same manner as polluting interests. The focus on this paper has been on how indirect lobbying can influence the public. However, no explanation is offered as to why environmental groups prefer to use this method. In particular, these groups are restricted from engaging in direct lobbying by assumption. In reality, green groups do make some contributions to the government, however spending in this manner is quite minimal. Extending the model to allow this behaviour may lead to an explanation for the preponderance of indirect over direct methods.

A second extension would be to consider other possible motives for educating the public. In particular, green groups receive funding from the government and direct from the public. It would seem reasonable to assume that both forms of funding might increase when the public believe environmental issues to be more important. As such, persuasion of may simply be a way of increasing revenues for green groups.

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Appendices

Appendix 1. Sending by the Green Lobby

As per Lemma 2, when the green lobby sends a message, the public will always believe it to be true. Thus a separating equilibrium exists such that: $\{m_G, m_F\} = \{\theta_H, 0\}; \mu = 1$. Numerical simulations below show conditions under which the green lobby will find it optimal to send a message. By Proposition 1, this is most likely when: (i) β is small, (ii) the upper bound of environmental damage θ_H is large, and when the public would otherwise believe damage to be very low. The effect of these variables on the payoffs from sending a message for the greens are examined below. Data in the tables reveal the net gain from sending a message, given exogenous parameter values. Negative values obviously imply that it is not optimal to send a message.

$\bar{\mu} \equiv$ posterior belief of public when greens do not send

$\beta \equiv$ weight attached to aggregate welfare by government

$\theta_H \equiv$ upper bound of environmental damage

Case 1: $\beta = 5; \quad \bar{\mu} = 0, 0.9; \quad \theta_H = 0.5, 1, ..., 5$

θ_H	$\bar{\mu} = 0$	$\bar{\mu} = 0.9$
0.5	*-0.58*	*-0.96*
1	*0.67*	*-0.83*
1.5	*2.75*	*-0.63*
2	*5.67*	*-0.33*
2.5	*9.42*	*0.04*
3	*14*	*0.5*
3.5	*19.4*	*1.04*
4	*25.6*	*1.67*
4.5	*32.8*	*2.38*
5	*40.6*	*3.7*

Case 2: $\beta = 3, 20; \quad \bar{\mu} = 0, 0.5, 0.9, 1; \quad \theta_H = 1$

$\bar{\mu}$	$\beta = 2.2$	$\beta = 3$	$\beta = 20$
0	*10*	*2*	*0.1*
0.5	*4.5*	*0.5*	*-0.4*
0.9	*0.1*	*-0.7*	*-0.9*
1	*-1*	*-1*	*-1*

Case 3: $\bar{\mu} = 0.9; \quad \theta_H = 2, 5$

β	$\theta_H = 2$	$\theta_H = 5$
2.2	*3.4*	*26.5*
3	*0.2*	*6.5*
5	*-0.33*	*3.2*
10	*-0.5*	*2.1*
50	*-0.6*	*1.6*

Appendix 2. Sending by the Firm.

For message sending to be optimal for the firm, it must be the case that the green lobby does not send a message. We thus begin by considering the green's strategy first. From proposition 1, it is evident that when β is large, or the upper bound of damage is low, it is less likely that the green lobby will send. The simulations below reveal the greens will not send under these conditions. For this, it is assumed that the beliefs of the public when the green do not send $\bar{\mu}$ are zero. In terms of off-equilibrium beliefs, this provides the strongest incentives for the greens to send. For any parameter values where the greens do not send when $\bar{\mu} = 0$, it is also the case that the greens will not send for any $\bar{\mu} > 0$.

Consider the following parameter values:

$\beta = 4, 6, ..., 20$
$\theta_H = 0.8$
$\bar{\mu} = 0$ (Belief of the public when greens do not send)

Table A1 Payoffs for Greens (high damage state)

β	Ω^G
4	*0.28*
6	*-0.04*
8	*-0.15*
10	*-0.2*
12	*-0.23*
14	*-0.25*
16	*-0.27*
18	*-0.28*
20	*-0.29*

Thus, for all cases other than $\beta = 4,$ it is not optimal for the greens to send.

Having identified cases where the greens do not send, we turn to the incentives facing the firm. Suppose that given these conditions, the firm were to find it optimal to send a message in the low damage state. In this situation, when actual damage is high, the firm can either send a message, in which case a pooling equilibrium occurs (Proposition 4), or it can not send. Note that if it follows the 'no send' option, the public will infer that damage is high (Proposition 5). This is because they expect to see a message from the firm when damage is low. The absence of a message would thus imply that damage is high. The possibilities can be examined using the following numerical example.

Consider first the incentives facing the firm in the low damage state. Assume that the public have a prior belief regarding damage such that $\lambda = 0.8,$ and that this belief is retained if they do not observe a message from the firm. Note once again that this is an off equilibrium belief, on which there are no restrictions. We will also assume that sending a message reduces this belief to 0.6. It is also assumed that *a* takes on a value of either 5 or 10. All other values remain the same as in table A1.

Simulations yield:

Table A2 Payoffs for the Firm (Low Damage State)

β	Ω^F (a=5)	Ω^F (a=10)
6	*1.13*	*3.53*
8	*0.89*	*3.03*
10	*0.78*	*2.78*
12	*0.71*	*2.62*
14	*0.66*	*2.52*
16	*0.62*	*2.45*
18	*0.60*	*2.39*
20	*0.58*	*2.35*

The results confirm that even if beliefs are only reduced to 0.6, the firm finds it optimal to send. Now consider the corresponding possibilities in the high damage state. If the firm does not send, then we have a separating equilibrium where the public believe that a message from the firm implies zero damage and that the absence of a message implies that they are in the high damage state.[32] On the other hand, if the firm does send, then a pooling equilibrium exists where the posterior belief is equal to the publics' prior. Thus,

$$\bar{\mu} \equiv \textit{posterior beliefs when the firm does not send} = 1$$

$$\tilde{\mu} \equiv \textit{posterior beliefs when the firm does send} = \lambda = 0.8$$

Again, numerical simulations are carried out. Given the importance of profits to the firm in devising its sending strategy, we again consider two levels: *a=5* and *a=10.* The results appear in the table below.

[32] Note than in Table A2, we have assumed that the public believe that the probability of high damage is 0.6 upon receiving a message from the firm. A posterior belief such that μ*=0,* will not violate the optimality of sending for the firm.

Table A3 Payoffs for the firm (high damage state)

β	Ω^F (a=5)	Ω^F (a=10)
6	*-0.13*	*2.27*
8	*-0.32*	*1.82*
10	*-0.4*	*1.59*
12	*-0.46*	*1.46*
14	*-0.5*	*1.36*
16	*-0.53*	*1.3*
18	*-0.55*	*1.25*
20	*-0.56*	*1.22*

These results demonstrate that both a pooling and separating equilibrium as described in Propositions 4 and 5 exist, given the parameters assumed. Other equilibria are surely possible, however the focus of this Appendix is solely to prove existence. Note that the pooling equilibrium becomes more likely when profits are high (higher value for a). Indeed, where a=5, the firm does not find it optimal to send in the high damage state, despite the fact that the public will take this to mean that damage is indeed high. Intuitively, the firm stands to gain more from influencing environmental policy under these circumstances and is thus prepared to incur the costs of deceiving the public. Note however, that knowing the strategy of the firm, the public place no weight on the messages.

Another interesting feature of this equilibrium is that the firm will only lie provided damage is not too large. This is not really due to the costs associated with sending a message, although these do rise in damage. However, it is always feasible that a will be sufficiently large to make sending optimal. However, the greens sending strategy is, as shown in Appendix 1, very sensitive to damage. If damage is large, the greens send and in doing so, effectively block the firm from engaging in indirect lobbying.

Appendix 3. Pooling Equilibrium with No Messages.

This equilibrium exists provided neither group is prepared to send in either state of damage. By Propositions 1 and 3, this would seem likely when damage is relatively low, the government places a large weight on aggregate welfare, and the profits earned by the firm are low. In short, these conditions imply that neither of then lobby groups stand to gain sufficiently by influencing the public to incur the costs of sending a message. We consider the case where:

$\theta_H = 0.1, 0.2, ..., 1$

$\beta = 100$

To conduct simulations, it is assumed that the prior belief of the public is 0.8. Thus, if no lobby sends, regardless of the true state of damage, the public will retain this belief. At the same time, the green lobby knows that if it sends a message, it will be believed. Thus, for the greens $\tilde{\mu} = 1$ and $\bar{\mu} = 0.8$.[33] Ω^G is thus given as:

Table A4 Payoffs for Greens

θ_H	Ω^G
0.1	*-0.998*
0.2	*-0.992*
0.3	*-0.982*
0.4	*-0.967*
0.5	*-0.949*
0.6	*-0.927*
0.7	*-0.9*
0.8	*-0.869*
0.9	*-0.835*
1.0	*-0.796*

This reveals that given the high weighting attached to aggregate welfare by the government $(\beta = 100)$ and the relatively low levels of environmental damage, the greens do not find it optimal to send, even though their message would be believed.

We now consider the incentives facing the firm. In addition to not sending in both states, the firm may choose to send only in the low damage state, inducing a separating equilibrium as described in Appendix 2. Again, we consider the incentives facing the firm in low damage first. On the equilibrium path, the posterior belief must be equal to the publics' prior of 0.8. Off the equilibrium path, it is assumed that the public would believe that damage is 0.6. Again, to highlight the importance of the firm's profits, two values for the parameter *a* are considered.

[33] Note that in this case we are considering an equilibrium where no group sends. Thus $\tilde{\mu}$, the belief when a message sent is the off-equilibrium belief on which there are no restrictions.

Table A5 Payoffs for the firm (low damage state)

θ_H	Ω^F (a=5)	Ω^F (a=10)
0.1	*-0.80*	*-0.60*
0.2	*-0.60*	*-0.20*
0.3	*-0.41*	*0.20*
0.4	*-0.23*	*0.59*
0.5	*-0.05*	*0.97*
0.6	*0.12*	*1.35*
0.7	*0.29*	*1.72*
0.8	*0.45*	*2.08*
0.9	*0.61*	*2.44*
1.0	*0.76*	*2.79*

These results reveal that given the set parameter values, the firm will not find it optimal to send in the low damage state for any level of damage lower than 0.6 when *a=5*. Intuitively, if the highest level of damage the public can believe to exist is very low, the gains from influencing them are low. Note also that if it is not optimal to send when damage is low, by Lemma 4, it is not optimal to send when damage is high. As such, the existence of a pooling equilibrium where no lobby sends a message is demonstrated. Note that a pooling equilibrium is far less likely when profits are higher. In particular, sending remains a viable strategy when *a*=10 for all values on the upper bound of damage greater than 0.2.

For interest, we can examine the strategy of the firm in the cases where the firm did send in the low damage state. As in Appendix 2, when damage is in reality high, the firm can either send, and a pooling equilibrium exists, or not send and a separating equilibrium exists. This implies that,

$$\bar{\mu} \equiv posterior\ beliefs\ when\ the\ \ firm\ does\ not\ send = 1$$

$$\tilde{\mu} \equiv posterior\ beliefs\ when\ the\ \ firm\ does\ send = \lambda = 0.8$$

Numerical simulations involving these beliefs yield the following:

Table A6 Payoffs for the firm (high damage state)

θ_H	Ω^F (a=5)	Ω^F (a=10)
0.1	*-0.9*	*-0.7*
0.2	*-0.82*	*-0.42*
0.3	*-0.76*	*-0.15*
0.4	*-0.71*	*0.11*
0.5	*-0.67*	*0.35*
0.6	*-0.65*	*0.57*
0.7	*-0.65*	*0.78*
0.8	*-0.66*	*0.97*
0.9	*-0.69*	*1.15*
1.0	*-0.74*	*1.31*

Again, where profits are lower, the firm does not send, as indicated by the negative values in column 2. However, as profits rise, the firm is more willing to send in both states, even though it invokes a pooling equilibrium as described in Proposition 4.